

# MEASUREMENT OF ABSOLUTE ELECTRON CAPTURE CROSS SECTIONS FOR $7 \times q$ keV $Fe^{q+}$ IONS IN COLLISIONS WITH $CO_2$

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Iron ions are important heavy ion constituents of the solar wind. These ions are present in highly charged states ranging from  $Fe^{7+}$  to  $Fe^{13+}$  with  $Fe^{10+}$  and  $Fe^{11+}$  being the most abundant<sup>1</sup>. Electron capture is an ion - molecule collision process which typically has a large cross section. Knowing its value for a particular ion/molecule pair is important for understanding the interaction of solar wind with comets and planetary atmospheres.

We have started a systematic experimental study of charge-changing cross sections for iron ions. The 14.0 GHz electron cyclotron resonance ion source (ECRIS), which is a key element of our highly charged ion facility<sup>2</sup>, allows us to obtain beam of all the above mentioned iron ions. For this purpose we are using ferrocene vapor  $C_{10}H_{10}Fe$  as the discharge-supporting gas.

For measurement of charge changing cross sections the retarding potential method is used for charge analysis of ions after they traverse the target-gas cell. The method is described elsewhere<sup>3</sup> and allows efficient study of collisional charge exchange. It can be used in three different ways:

(1) scanning the  $M/q$  spectra with low retarding field, and retarding field high enough to eliminate the parent ions. This allows fast screening of the charge changing efficiency for groups of ions at a fixed acceleration voltage. An example is shown in Fig. 1. (2) measurement of ion current variation with target gas pressure for different retarding fields. The low pressure slope determines the cross section. Its detailed shape reveals the presence of metastable ions in the incident beam. (3) consecutive measurement of transmitted current for a chosen ion and at fixed pressure, for different retarding fields. This affords the fastest determination of cross section at particular ion energy.

Electron capture cross sections for  $Fe^{q+}$  in  $CO_2$  were measured at  $7 \times q$  keV and for  $q$  from 5 to 11. Measurements in  $CO$  are in progress.

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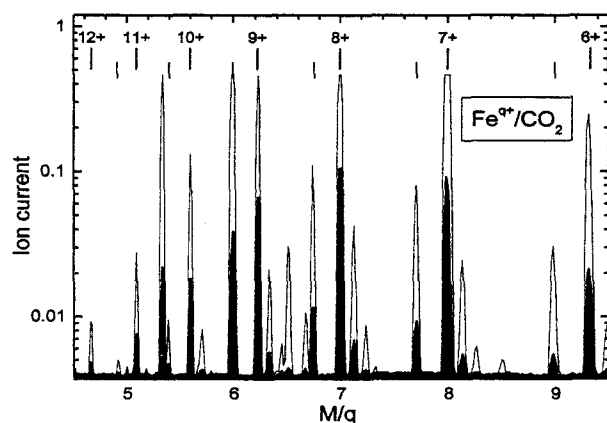


Figure 1.  $M/q$  spectra for different retarding potentials: 6.8 kV (light full line) and 7.2 kV (filled-in peaks). Positions of  $^{56}Fe^{q+}$  and  $^{54}Fe^{q+}$  are indicated. The ion acceleration voltage was 7 kV and the ECRIS microwave power was 28 W.

## References

1. R. Wegmann, H. U. Schmidt, C. M. Lisse, K. Dennerl and J. Englhauser, *Planet.Space. Sci.* **46**, 603 (1998).
2. A. Chutjian, J. B. Greenwood, and S. J. Smith, in *Applications of Accelerators in Research and Industry* (ed. J. L. Duggan and I. L. Morgan, AIP Conf. Proc. 475, AIP, New York, 1999).
3. J. B. Greenwood, I. D. Williams, S. J. Smith, and A. Chutjian, *Phys. Rev. A* (in press); J. B. Greenwood, A. Chutjian, and S. J. Smith, *Astrophys. J.* **529**, 605 (2000).

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